National Aeronautics and Space Administration

NASA

EXPLORESPACE TECH

Lunar Surface Innovation Initiative (LSII) Overview

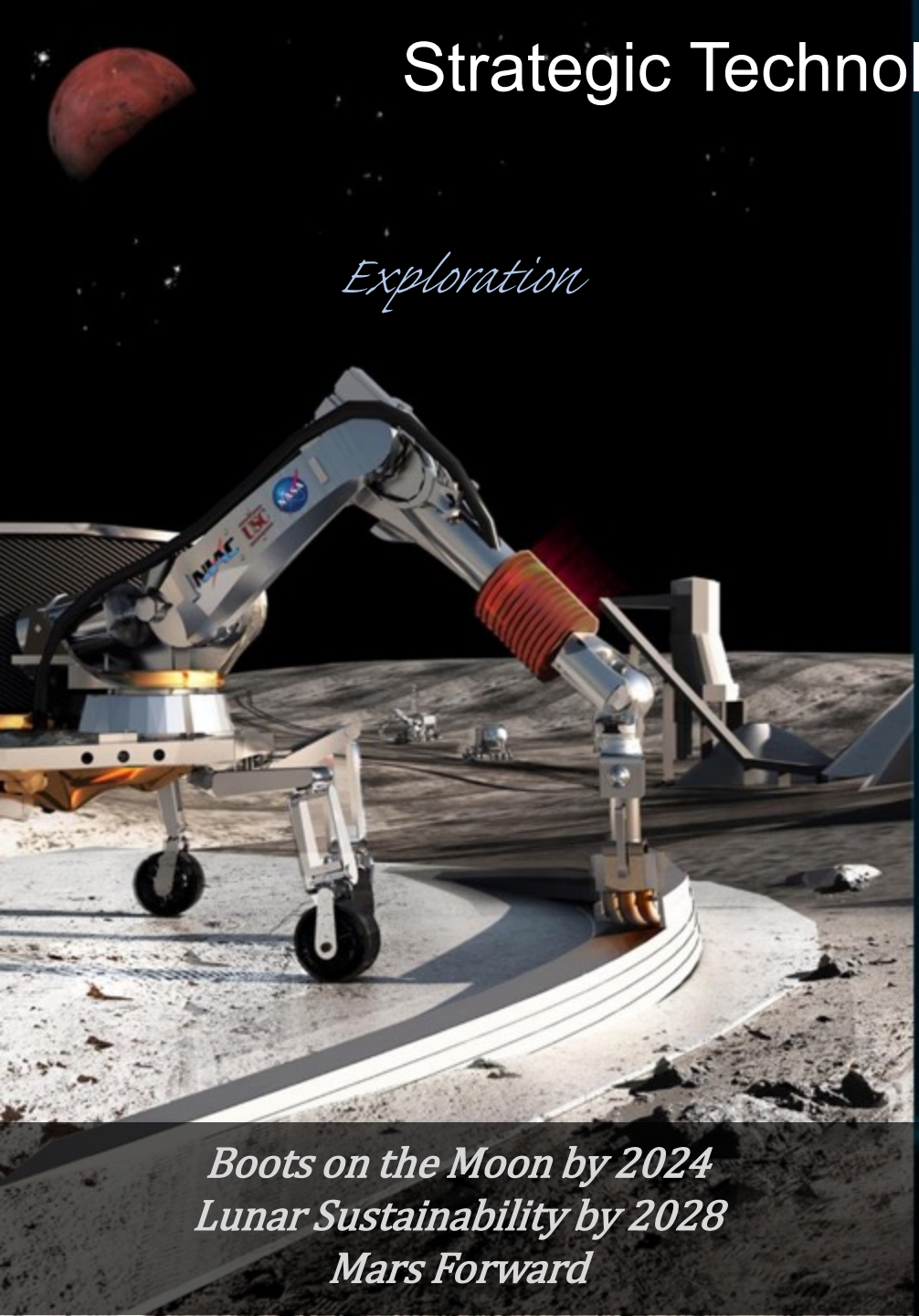
NAC Technology, Innovation, and Engineering Committee Meeting

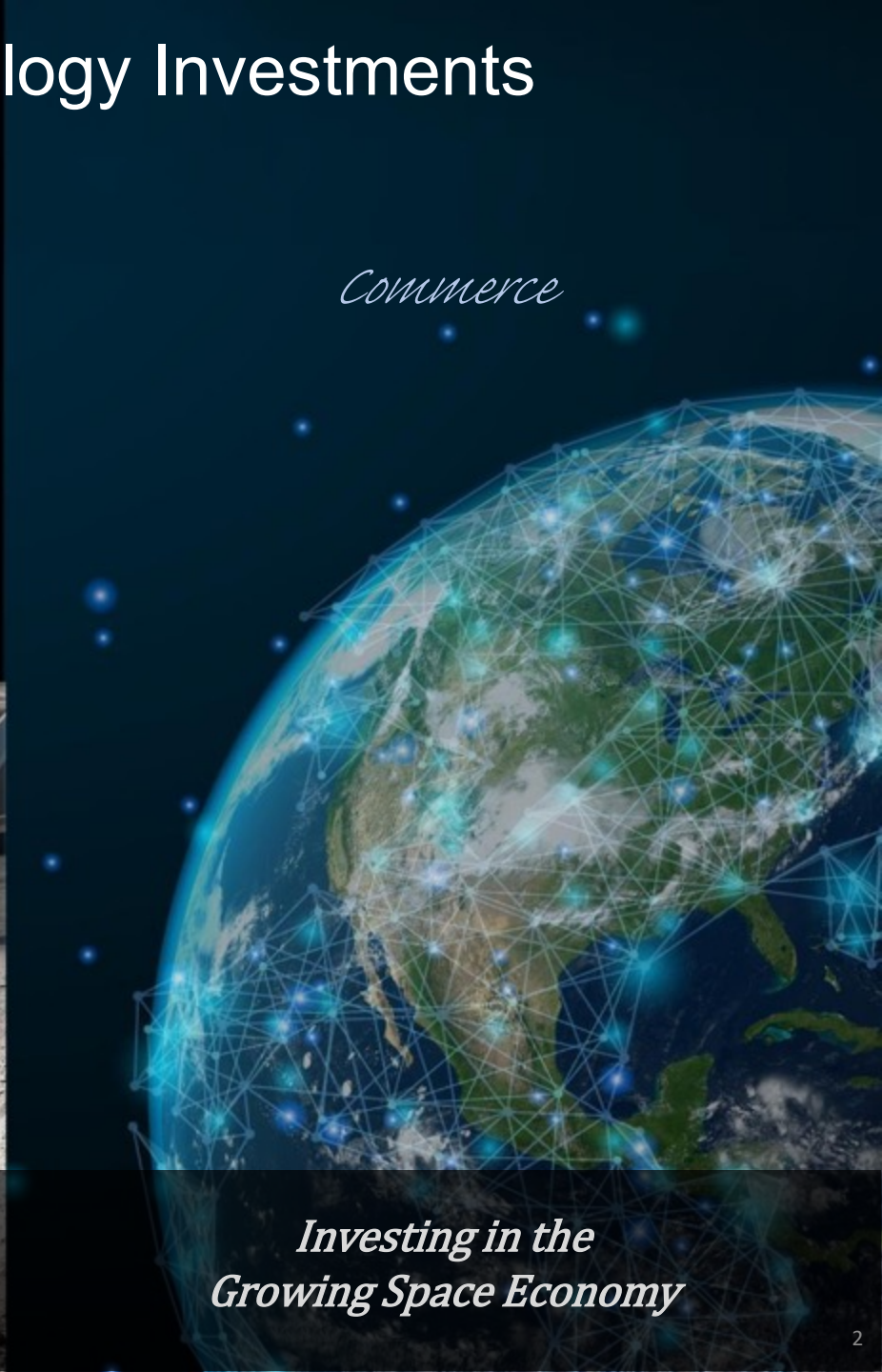
Niki Werkheiser, NASA STMD, LSII Lead | October 29, 2019

Strategic Technology Investments

Exploration

Commerce

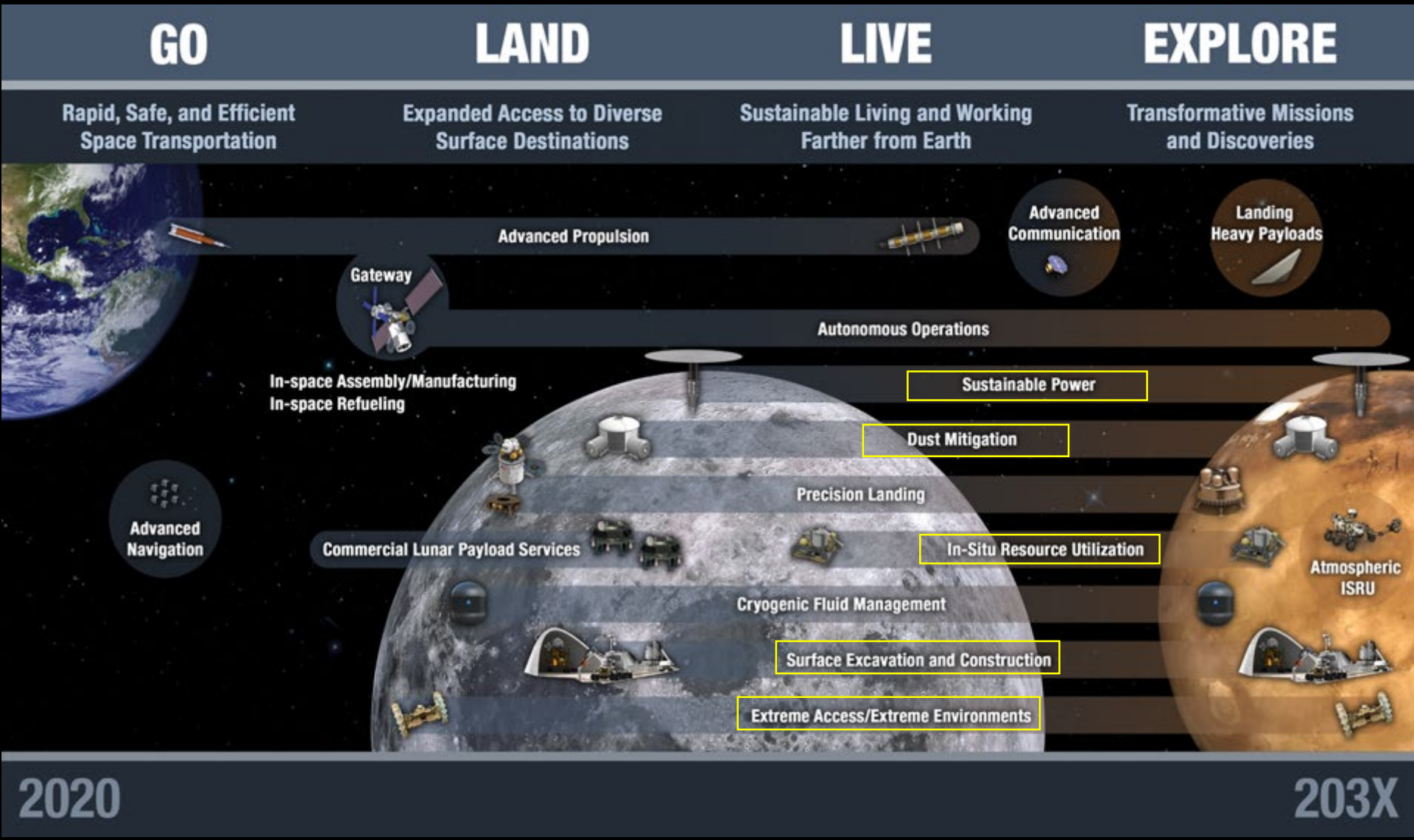




Boots on the Moon by 2024
Lunar Sustainability by 2028
Mars Forward

Investing in the
Growing Space Economy

Technology Drives Exploration



Lunar Surface Innovation Initiative (LSII)

The Lunar Surface Innovation Initiative (LSII)

The Lunar Surface Innovation Initiative (LSII) aims to spur the creation of novel technologies needed for lunar surface exploration and accelerate the technology readiness of key systems and components. The LSII activities will be implemented through a combination of unique in-house activities, competitive programs, and public-private partnerships.

LSII Roles and Responsibilities Include:

- Ensuring that there is an ambitious, cohesive, executable Agency strategy for development and deployment of the technologies required for successful lunar surface exploration.
- Integrating a broad spectrum of stakeholders to develop an acquisition strategy which efficiently facilitates robust collaborations and partnerships with industry and academia.
- Addressing planning, implementation, and budget needs to enable lunar surface activities across the Space Technology Mission Directorate (STMD) Programs.
- Collaborating with Agency stakeholders (across Mission Directorates, NASA Centers, etc.), as well as Other Government Agencies (OGAs), universities, industry, and international partners in order to better align the Agency's investments relative to lunar surface demonstrations.

The Lunar Surface Innovation Initiative (LSII)

In Situ Resource Utilization

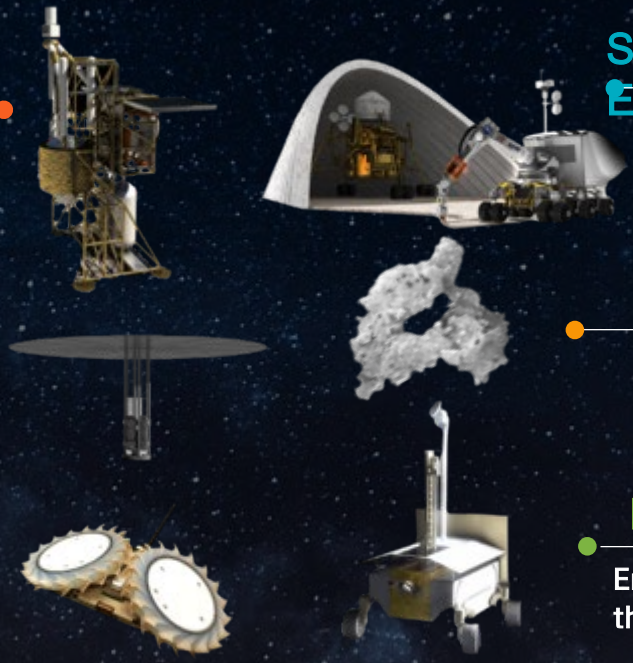
Collection, processing, storing and use of material found or manufactured on other astronomical objects

Sustainable Power

Enable continuous power throughout lunar day and night

Extreme Access

Access, navigate, and explore surface/subsurface areas



Surface Excavation/Construction

Enable affordable, autonomous manufacturing or construction

Lunar Dust Mitigation

Mitigate lunar dust hazards

Extreme Environments

Enable systems to operate through out the full range of lunar surface conditions

- **STMD develops and performs demonstrations that allow the primary technology hurdles to be retired for a given capability at a relevant scale. While there may be additional engineering development required for additional scale-up, there should be none required for the foundational technologies.**
- **LSII will accelerate technology readiness for key lunar infrastructure capabilities enabling early technology demonstrations for early un-crewed commercial missions, as well as informing development of crewed flight systems.**

Lunar ISRU Development and Demonstration Timeline

Reconnaissance, Prospecting, Sampling

Sub-system Demonstrations: Investigate, sample, and analyze the environment for mining and utilization.

Resource Acquisition & Processing

Follow The Natural Resources: Demonstrations of systems for extraction and processing of raw materials for future mission consumables production and storage.

Pilot Consumable Production

Sustainable Exploration: Scalable Pilot Systems demonstrating production of consumables from in-situ resources in order to better support sustained human presence.

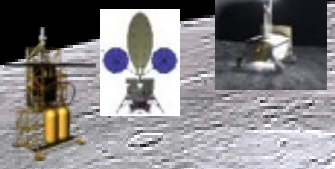
Oxygen from Regolith (Lunar Simulant) Ground Demos

High-fidelity Lunar Simulant Production

CLPS Drill Down-Select

Polar Resources Ice Mining Experiment (PRIME-1) on CLPS

ISRU Subsystem Consumables Extraction Demos



Scalable Pilot-ISRU Systems for Consumable Production

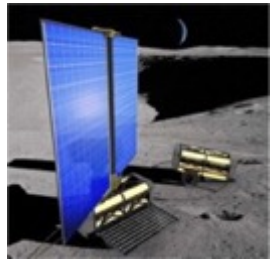
2019

Lunar Surface Power

STMD is developing technologies which can provide the capability for continuous power throughout day and night for Lunar Surface missions.

Technology Developments Underway:

- Power Generation
  - Fission Surface Power
  - Adaptable Lunar Lander Solar Array Systems
  - Chemical Heat Integrated Power Source
- Regenerative Fuel cell (RFC) for Energy Storage



Additional Investments:

- Conducting a phased, system level assessment of power architecture for lunar surface missions
- Primary Fuel Cell Technology Tipping Point to demonstrate fuel cell element on early lander using propellant-grade hydrogen and oxygen reactants to extend the lander surface mission duration
- Technology development efforts initiated for surface-to-surface power beaming, advanced rover energy storage technology and power distribution architectures.

LSII Collaborative Leveraging

A key tenet of LSII is to implement a multitude of novel collaborations across industry, academia, and government in order to successfully develop the transformative capabilities for lunar surface exploration.

- ISRU NextSTEP BAA's, including component and subsystem testing in simulated space environments
- Centennial Challenges is providing lunar and Mars-forward capabilities for LSII, including:
  - Space Robotics Challenge (Ph. II kicked off in August 2019)
  - ISRU Production Challenge which builds on the success of the 3D Printed Habitat Challenge (In formulation)
  - Portable energy storage challenge to enable powering a rover through several cycles of lunar daylight and darkness (In formulation)
- The first NIAC Phase III Award to Carnegie Melon for, "Technologies Enabling the Exploration of Lunar Pits".
- YET2 worldwide technology search for LSII topics through the NASA Center of Excellence for Collaborative Innovation (CoECI). Ensures that NASA is pushing the competitive edge and helps to identify non-traditional industries with relative capabilities.
- Actively pursuing SBIR/STTR awards that can directly infuse into LSII, as well as exploring additional ways that the SBIR process can be effectively utilized for targeted, high-value, early surface activities.

Centennial Challengses 3D Printed Habitat, Level 1 Winner: Zopherus

SBIR/STTR

NIAC
NASA Innovative Advanced Concepts

Center of Excellence for Collaborative Innovation

University Affiliated Research Center (UARC) as the LSII System Integrator

At the June 28th NASA Acquisition Strategy Council (ASC), STMD:

- Provided a response to an action to assess engagement of existing FFRDCs/UARCs in lunar surface activities.
- Received approval to utilize the existing APL contract to initiate a task to provide a feasibility assessment on the structure, scope, cost and roles and responsibility of a UARC to support a system integration role for the Lunar Surface Innovation Initiative.
- Received action to provide summary of findings and recommendations to an Acquisition Strategy Meeting NLT the end of CY 2019.

An initial task was awarded to APL on 8/16/19 to provide the following:

- Assessment/Study on System Integration Role: Perform a detailed assessment on utilizing a UARC as an LSII system integrator to ensure delivery of component technologies and integrated systems for ground testing or to a lander provider for delivery to the Lunar surface. As part of this assessment, the UARC will study the formulation of a **Lunar Surface Consortium** composed of industry, academia, and NASA with expertise in LSII key capability areas.
- Lunar Surface Power and ISRU System Architecture and Integration Assessment: Work in an integration role starting with lunar surface power and ISRU activities. Products will include an architecture and integration assessment and an initial Concept of Operations.

Lunar Surface Innovation Consortium

Key Consortium Tenets

- Technology – Develop key lunar infrastructure capabilities
- Collaboration – Enable meaningful partnerships that leverage common objectives for establishing lunar infrastructure.
- Communication – Create information paths to best match needs with opportunities
- Future Workforce – Ensure the U.S. maintains the workforce needed for sustained space exploration

The Consortium Will…

- Identify lunar surface technology needs and assess the readiness of relative systems and components
- Make recommendations for a cohesive, executable strategy for development and deployment of the technologies required for successful lunar surface exploration
- Provides a central resource for gathering information, analytical integration of lunar surface technology demonstration interfaces, and sharing of results

***Example Operational* Models**

SRC Semiconductor Research Corporation

COMMERCIAL SPACEFLIGHT FEDERATION

USRA

Timeline:

- June - October – Industry-wide inquiry and outreach
- November – APL submits recommendations to NASA STMD
- December – NASA Acquisition Strategy Council (ASC) Review
- January – Kick-off Consortium

The purpose of the consortium is to harness the creativity, energy and resources of the country in order for NASA to keep the United States at the forefront of Lunar Exploration

Technology Drives Exploration